



Plenary Session: MTO and the Outside World

Dr. John Zolper

Vice President of Corporate
Research & Development
and Deputy for Corporate
Technology & Research, Raytheon

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DARPA MTO Symposium



Air
Land
Sea
Space
Cyberspace

Innovation. In all domains.

Microsystems for a Changing Battlespace

John Zolper, Ph.D.
Vice President
Research & Development
Raytheon Company

March 3, 2009

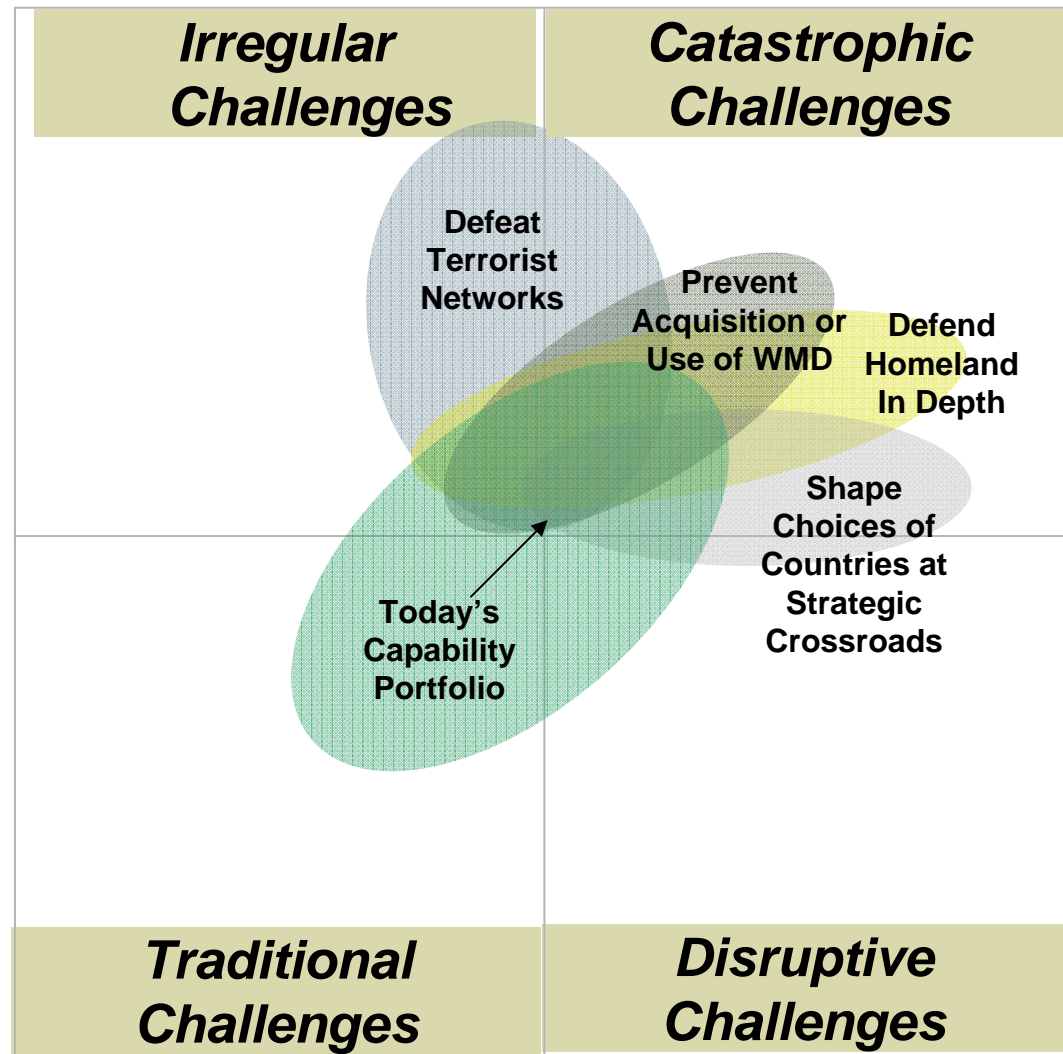
Challenges From Multiple Fronts: Rapidly Evolving and Diverse Threats

Asymmetric

- Unpredictable
- Rapidly evolving and highly adaptable
- Decentralized C2
- Highly effective low-tech threats
- Indiscriminant targeting – civilians, military, infrastructure

Near-peer

- Focused defense strategy
- Rapidly growing military capabilities
- Centralized C2
- Rapid evolution in advanced technologies
- Focused targets – military, infrastructure



U.S. strategy must encompass terrorist networks to near-peer competitors

Challenge: Low Cost Asymmetric Disruptors

- Denial of service, disruption, deception, destruction
 - Information Operations (only takes a laptop and an internet connection)
- Degradation of GPS, communications, radar systems
 - Low cost rf jammers (digital and rf COTS electronics widely available)
- Increased instability, highly unpredictable, rapid evolution
 - SAMs, RPGs, IEDs (wide availability of low cost electronics and munitions)
- Disruption, deception, destruction of satellite operation
 - Nano-satellites
 - Laser dazzler
- Surreptitious surveillance, unpredictable destruction
 - Small & Mini-UAVs (growing UAV proliferation)

Asymmetric disruptors enabled by low cost COTS

Challenge: Near-Peer Disruptors Advancing Rapidly

- Harder to detect & counter: shortens our kill chain
 - Highly Mobile Theater Ballistic Missiles
 - Increasing sophistication of Camouflage, Concealment, and Deception
 - Lower Observable Cruise Missiles
 - Weaponized UAVs
- Deny US surveillance & access to their territory
 - Hard Deeply Buried Facilities
 - High Energy Lasers
- Achieve precision nav, global comm, 24/7 surveillance
 - Nav, Comm, Imaging Satellites
 - Expanding community for space access

Adversaries have national strategy with focused R&D

Challenge: Asymmetric Threat Undermining U.S. R&D Prowess

- **System reverse engineering**
 - **Enables compressed development cycle for our adversaries**
 - **Dramatically reduces cost of weapon system development**

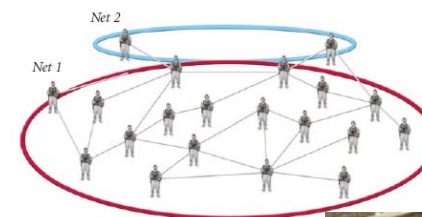
- **Technology transfer**
 - **“Through any and all means necessary” activity to counter US economic and engineering advantage**

- **Multiple conflicts lead to increased opportunity for adversary**
 - **Battlefield loss of critical technology & information**
 - **Export**

Adversaries clone our weapon systems to reduce R&D cost

Challenge: Information Assurance in a Highly Information Dependent and Networked World

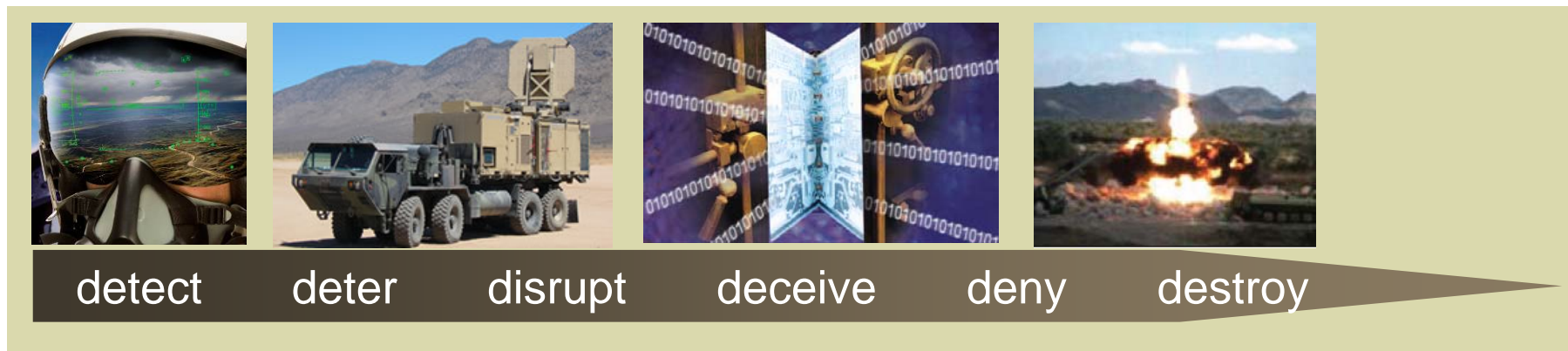
- Asymmetric strategies exploit our weaknesses:
 - Highly information dependent
 - Technology dependent
 - Large investment in space & air-power
 - GPS-dependent
- Trends:
 - Increased net-centricity & info sharing
 - Net-enabled weapon systems
 - Service-Oriented Architectures (SOA)
 - Tech adoption before vulnerabilities are understood
 - Virtual machines, SOA, VOIP
 - Untrustworthy supply chain
 - Off-sourcing of COTS hardware, software, firmware



How do we protect our information in an info-sharing world?

Challenge: Cross Domain Dominance

- Cross domain dominance: Ability to span entire spectrum of effects to *detect, deter, disrupt, deceive, deny, destroy*



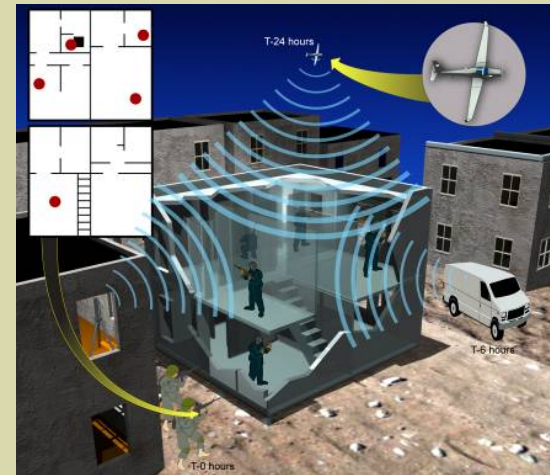
- Maximize knowledge of information on “object”
 - Leverage multi-functionality, multi-frequency, multi-spectral, multi-INT
- Rapidly link discoveries
 - Extracting Knowledge from information from data
- Ensure information assurance and anti-tamper

“Problems cannot be solved by thinking within the framework in which the problems were created” – Albert Einstein

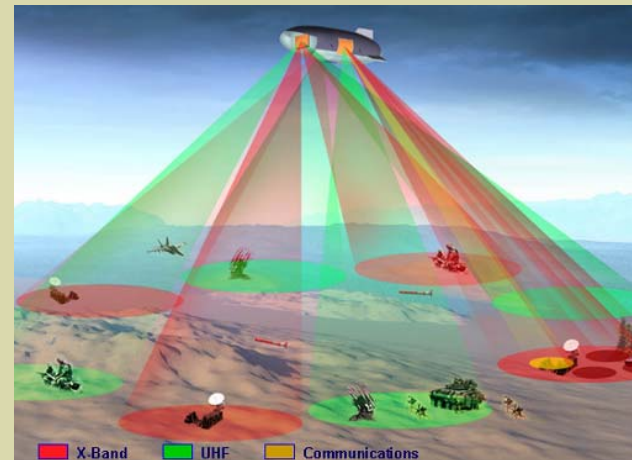
Challenge: Respond to Threat Evolution with Multifunction RF Systems

■ Evolution towards

- Multi-functional systems
- Multi-frequency
- Multi-mode
- Multi-static
- Low cost, light weight
- Integrated structure
- Soft programmable



DARPA VisiBuilding



DARPA Integrated Structure is Sensor (ISIS) Program

Sensing

Challenge: Tactical High Power Lasers and Beam Controllers

■ Current laser systems:

- Utilize gimbals
- Mounted in turrets

■ **Problem**: Turret creates drag & turbulence

- Reduces mission duration
- Limits platform speed
- Degrades beam



Paradigm Shift:

- APPLE fiber laser beam steering
 - Electronically steered
 - Conformal mount
 - Modular & scalable architecture



Significant reduction in size, weight, and power



Airborne tactical laser

Applications:

- High energy laser
- Laser communications
- Search & track

Effects

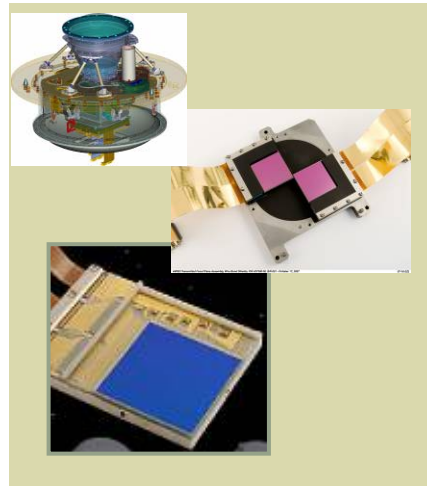
Challenge: Maintaining the Edge in EO Sensing through 3rd Gen Technology

Raytheon

Si PIN



Large Format IR



Advanced Uncooled



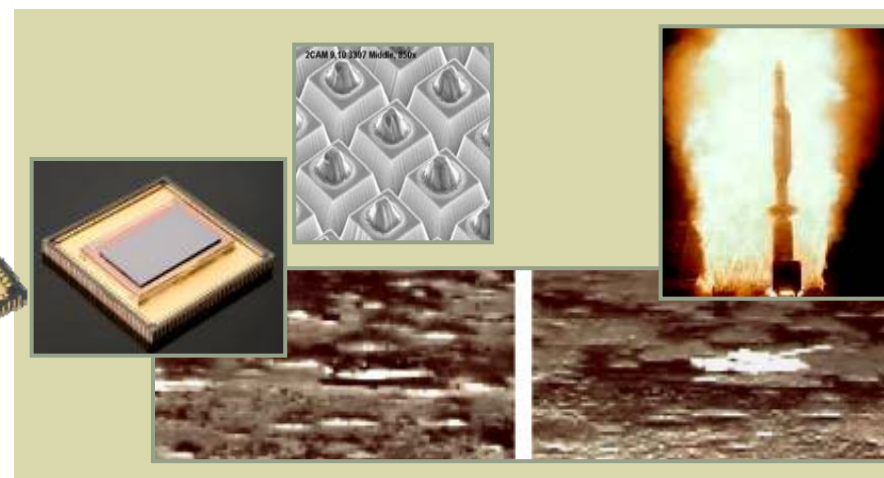
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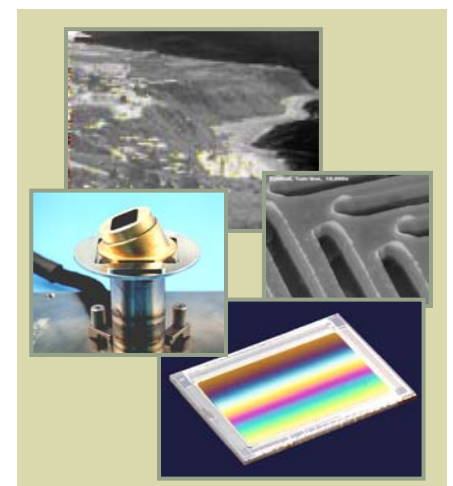
SWIR



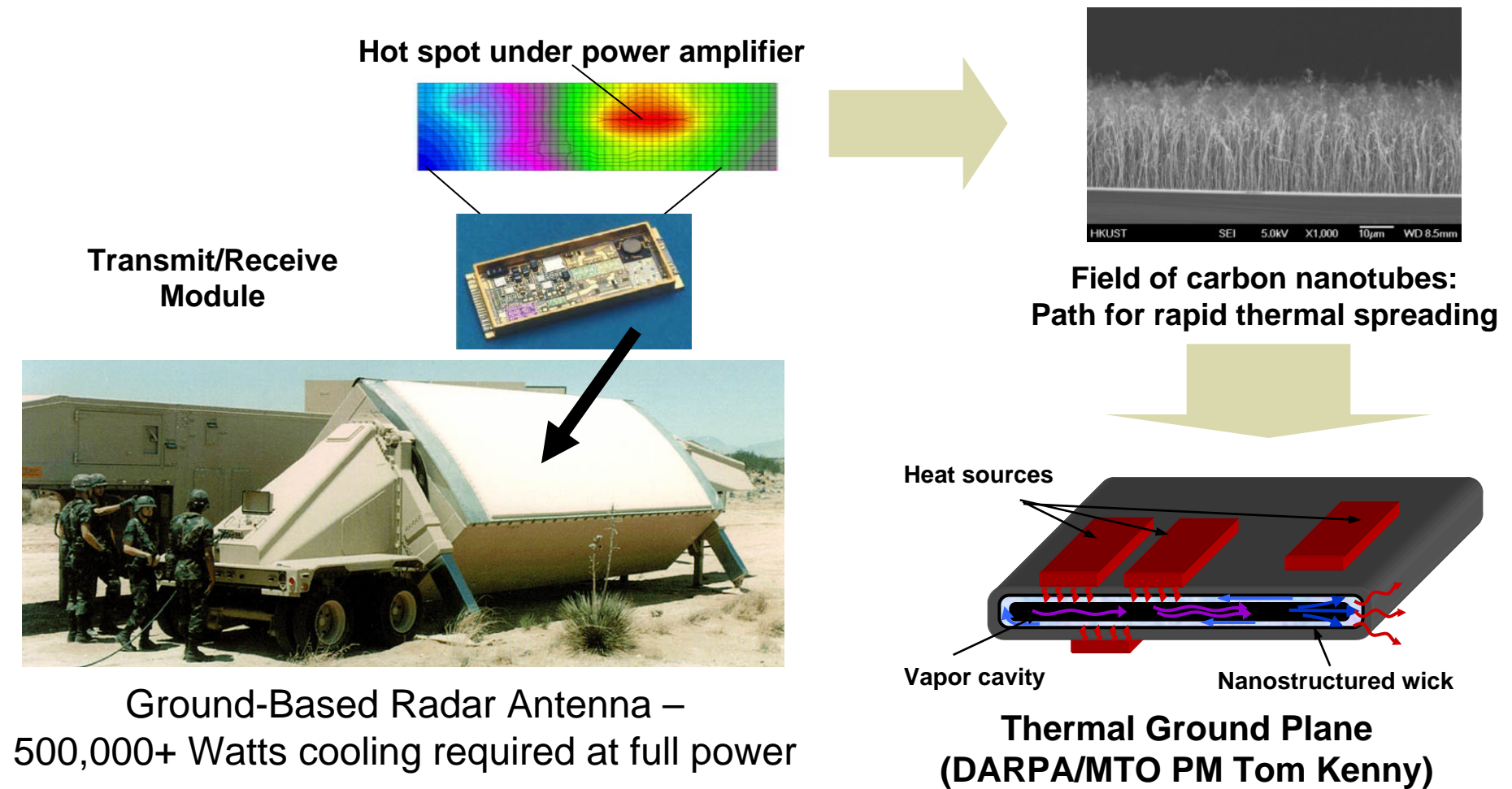
Dual Band



**Polarimetry/
Hyperspectral**



Challenge: Thermal Management of High Power Electronic Systems



**Engineered nanomaterials enable cooler electronics =
higher reliability and higher performance**

Challenge: Maintaining Dominance of the Electromagnetic Spectrum

NEXT: DARPA/MTO
PM Mark Rosker

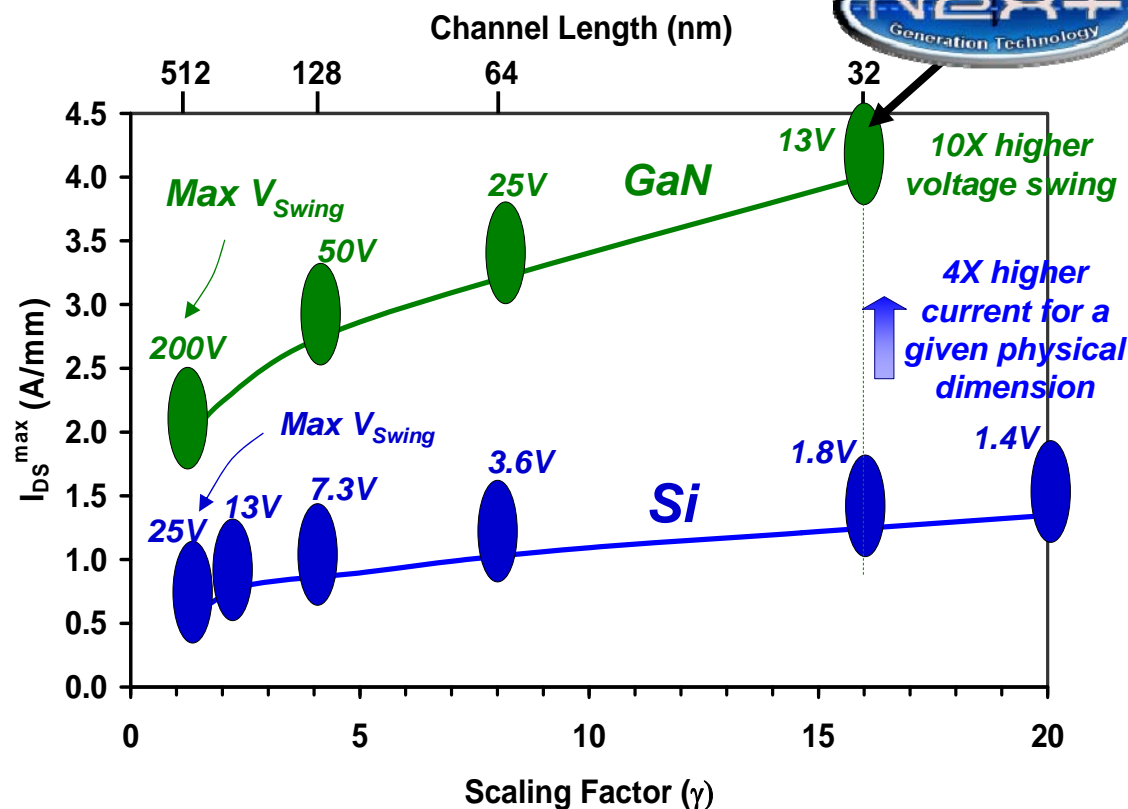


Program Objectives

- Develop a high performance nitride transistor for high speed RF, analog, and mixed signal electronics
 - I_{DS} levels 4X better than SOA Si
 - Voltage swings 10X more than Si
 - Enhancement mode operation
- Enable high integration level
 - High yield transistor process
 - Uniform
 - Reliable

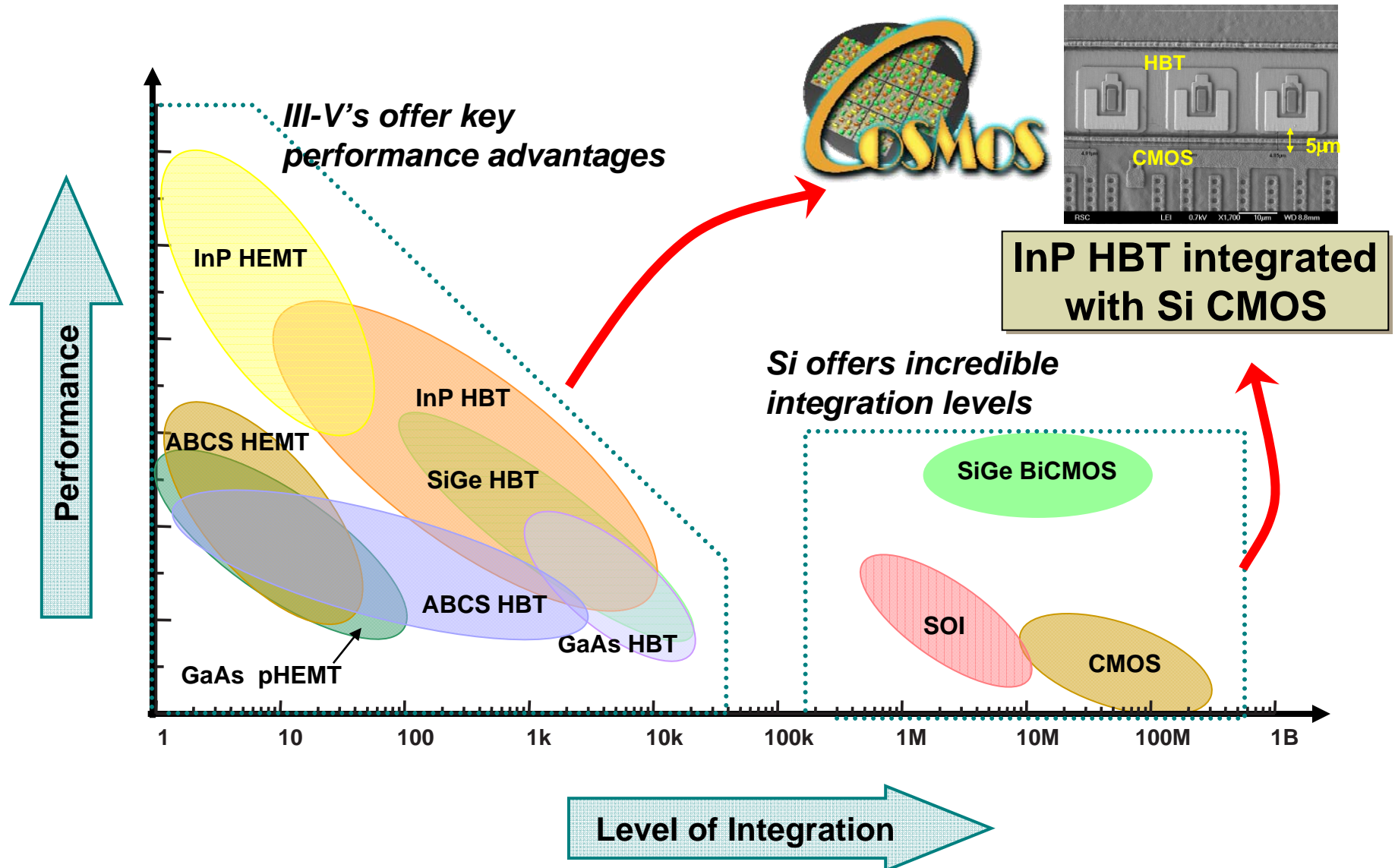
Impact

- High dynamic range mixed-signal electronics
 - Would enable wideband power DACs with >100X increase in output power
 - Also enables 25 dB improvement in mixer IP3
- Enables complex E/D logic circuits
 - Ultra-low gate delay



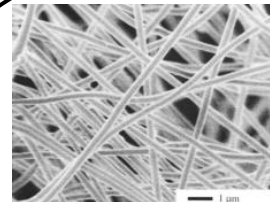
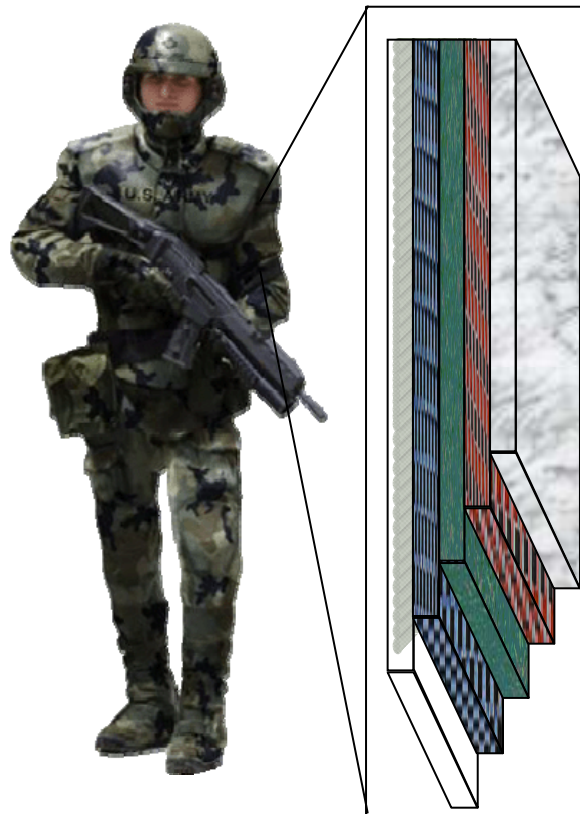
High frequency, high dynamic range, solid state technology opens new EM opportunities

Challenge: Discriminating Circuit Performance at an Acceptable Cost Point

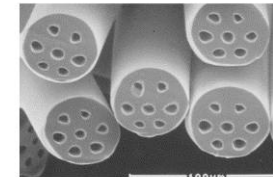


Challenge: Soldier Battlesuit for CBNRE Protection and Networked Connectivity

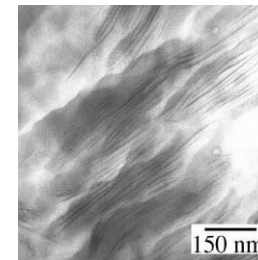
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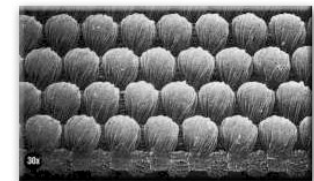
Nanofibers



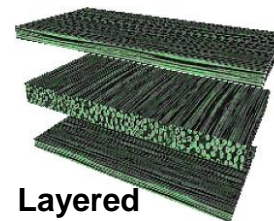
Microfluidics



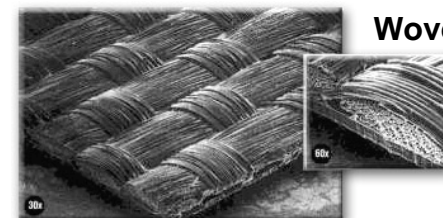
Nanocomposites



Nanostructures

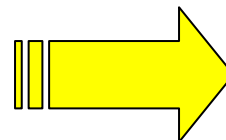


Layered Nanostructures



Woven-Materials

The Battlesuit:
Layers of Multifunctional Nanomaterials
Systems of Nanosystems



**Massive Functionality
with Decreased Weight & Volume**

Nanotechnology advances ripe for integrated solution.

Additional Microsystems Challenges

Sensing

- Room temperature broadband EO sensing
- Chip-scale hyper-spectral sensing
- Multi-domain imaging
- Linear, efficient, broadband RF
- Sensors for stand-off biometrics
- Efficiency

Processing

- Heat dissipation and management
- Latency and communication
- Complexity and parallelism in circuit design
- Analog to digital conversion
- Trusted ICs
- Exploiting entangled systems

Communication

- Spectral efficiency
- Reduced latency
- mm-wave communications

Actuation

- Universal MEMS packaging
- Ultra-stable, lower power timing devices
- Robust, efficient actuation

Energize

- Efficient, high power lasers
- Smart power management
- High energy density storage
- Efficiency, efficiency, efficiency

Summary

- The rapidly changing world and battlespace makes the delivery of rapid, innovative solutions more critical than ever for the DoD.
- Microsystems remain at the core of new system concepts and new capabilities for the warfighter.
- A strong DARPA, industry, university, and government partnership is critical to continue to deliver timely solutions to the warfighter.

MICROSYSTEMS TECHNOLOGY OFFICE

MTO SYMPOSIUM

The logo for the Microsystems Technology Office (MTO) Symposium. It features the letters 'MTO' in a large, bold, metallic font. The 'O' is a circle containing a globe with the word 'DARPA' on it. Circuit traces extend from the 'M' and 'O'. Below 'MTO' is the word 'SYMPOSIUM' in a smaller, white, sans-serif font. The entire logo is set against a dark background with a reflection effect below it.

BUILDING THE FUTURE
FROM THE INSIDE OUT

The background of the poster is a collage of various technological and infrastructure elements. On the left, there's a large satellite dish and a solar panel array. In the center, a ship's mast with various antennas and sensors is visible. On the right, there's a large, complex structure that looks like a space station or a large industrial facility. The entire background is in shades of blue and white, with a grid pattern overlaid.

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